

# The Web as a Knowledge-Base for answering complex questions

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# Complex Questions

List the U2 concerts that will be held in Europe on a weekend near a Marriott

All News Images Maps Videos More Settings Tools

About 9 results (0.59 seconds)

U2 > Tours > U2 eEXPERIENCE + iNNOCENCE Tour 2018

[www.u2.com/tour](http://www.u2.com/tour)

eEXPERIENCE & iNNOCENCE Tour heading to North America from May to July and Europe from August to November. #U2eiTour #U2SongsofExperience 'Augment Your Reality.' Download the U2 AR eEXPERIENCE app before reaching the venue and trigger ..... Email List · Terms + Conditions · Privacy · Help · Translate.

Missing: marriott

Settings Tools

Recent NAACL?

Evaluating Natural Language Understanding Services for ...

[https://www.researchgate.net/publication/319127909\\_Evaluating...](https://www.researchgate.net/publication/319127909_Evaluating...)

Evaluating Natural Language Understanding Services for Conversational Question Answering Systems.

... Recent publications have discussed the usage of.

# Existing approaches

# Existing approaches: Semantic parsing

How many subsidiaries does Apple have?



**Count**( $\lambda x.$  **Type**( $x$ , **Subsidiary**)  $\wedge$  (**Parent**( $x$ , **Apple**))



(Execute on Knowledge-base)

**Answer: 3**

**Advantages:**

- **High compositionality**

**Disadvantages:**

- **Low coverage**
- **Requires schema**

# Existing approaches: Reading comprehension

**What did Marilyn Monroe die from?**

Marilyn Monroe was found dead of a barbiturate overdose in the early morning hours of Sunday, August 6, 1962, at her 12305 Fifth Helena Drive home in Los Angeles, California.

**Answer: barbiturate overdose**

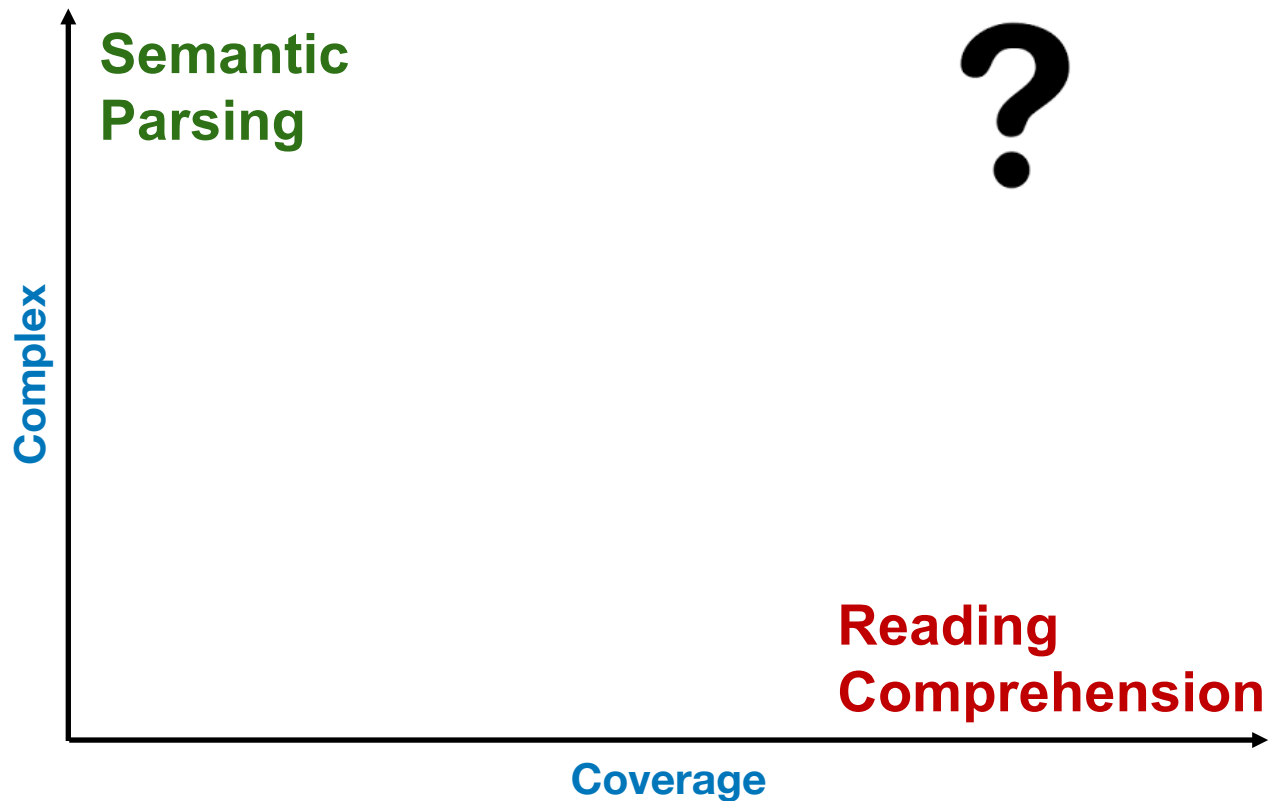
**Advantages:**

- Does not require schema
- Wide coverage

**Disadvantages:**

- Assume paragraph given
- Struggles with compositionality

# Present



# Approach overview

# Observations

where is the birthplace of jazz?



Birthplace of Jazz - **New Orleans**

[www.neworleansonline.com/neworleans/music/musichistory/jazzbirthplace.html](http://www.neworleansonline.com/neworleans/music/musichistory/jazzbirthplace.html) ▼

Birthplace of Jazz. In the late 19th century, while the rest of America was stomping their feet to military marches, and New Orleans was dancing to VooDoo rhythms. New Orleans was the only place in the New World where slaves were allowed to own drums.

BBC - Travel - The birthplace of jazz

[www.bbc.com/travel/story/20120224-travelwise-the-birthplace-of-jazz](http://www.bbc.com/travel/story/20120224-travelwise-the-birthplace-of-jazz) ▼

Feb 24, 2012 - The birthplace of jazz. How New Orleans became the breeding ground for a uniquely American art form.

The Birthplace of Jazz | Experience New Orleans!

[www.experienceneworleans.com/jazz-birthplace.html](http://www.experienceneworleans.com/jazz-birthplace.html) ▼

Jazz...the sound that put New Orleans on the map, musically speaking! It's a distinctive sound—not big-band swing, with horns creating harmony. Nor is it modern ...

**Answer: New Orleans**

**Assumption:**

**Answering simple questions is possible with a search engine and a reading comprehension model**

**Apply reading comprehension**

**Thus, the missing piece is broad and complex question understanding**



# Approach Example

*“What is the population of the largest economy in Europe?”*



Decompose

*“largest economy in Europe”*



Query

# Approach Example

largest economy in europe

All Images News Maps Videos More Settings Tools

About 8,930,000 results (1.05 seconds)

**Europe's largest national economy** is that of Germany, which ranks fourth globally in nominal GDP, and fifth in purchasing power parity (PPP) GDP; followed by the United Kingdom, ranking fifth globally in nominal GDP, followed by France, ranking sixth globally in nominal GDP, followed by Italy, which ranks seventh ...

[Economy of Europe - Wikipedia](https://en.wikipedia.org/wiki/Economy_of_Europe)  
[https://en.wikipedia.org/wiki/Economy\\_of\\_Europe](https://en.wikipedia.org/wiki/Economy_of_Europe)



Country	Approximate Nominal GDP (USD)
Germany	\$420,000
France	\$300,000
Italy	\$280,000
UK	\$270,000
Spain	\$180,000
Netherlands	\$170,000
Sweden	\$160,000
Poland	\$150,000
Austria	\$140,000
Belgium	\$130,000
Denmark	\$120,000
Finland	\$110,000
Switzerland	\$100,000
Ireland	\$90,000
Norway	\$80,000
Luxembourg	\$70,000

About this result • Feedback

Answer

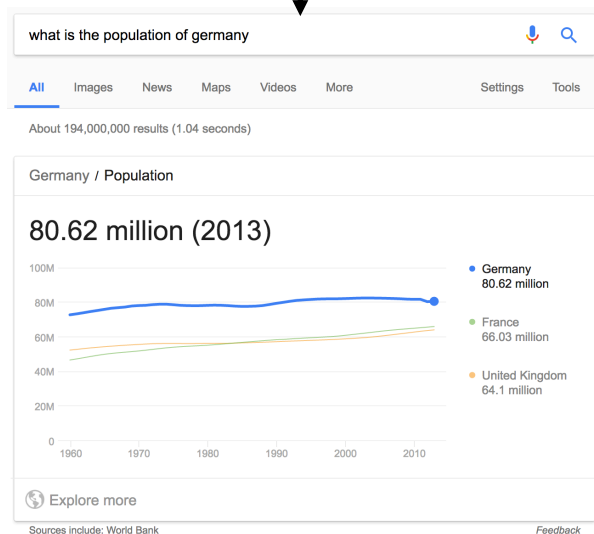
Germany

# Approach Example

Compose

*“What is the population of Germany?”*

Query



Answer

80.62M

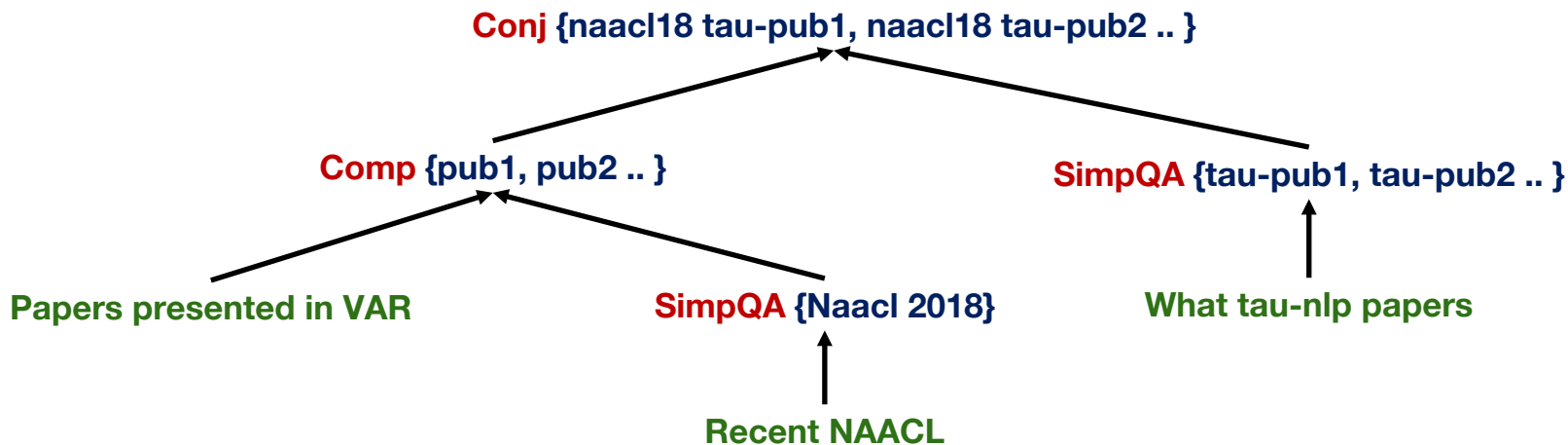
# Contributions

- A **framework** for answering broad and complex questions through question decomposition
- Pointer-generator network for question decomposition
- New **dataset**: ComplexWebQuestions

# Framework

# Task definition

What tau-nlp papers were presented in the recent NAACL?



computation tree

- **Leaves:** strings - not necessarily in the input!
- **Inner nodes:** semantic functions
- **Denotations**  $[t] = f([c_1(t)], \dots, [c_k(t)])$

# Dataset Generation

## 1. Seed Question, WebQuestionsSP

*Where is the euro 2012 tournament?*

?x ns:sports.event.host 2012\_tournament.



## Add compositionality (auto)

## 2. Add compositionality using Freebase

?x ns:sports.event.host 2012\_tournament.

?x ns:location.location.people\_born\_here ?y.

?y ns:book.author.book\_published ns:m.04xq3nb.



## Generate pseudo language (auto, Wang et al. 2015)

## 3. Generate machine questions

*Where is the euro 2012 and is the place where the publisher of the book Without End was born?*



## Convert to natural language (human)

## 4. Paraphrase using Amazon Mechanical Turk

*What city is the birthplace of the author of Without End and hosted Euro 2012?*

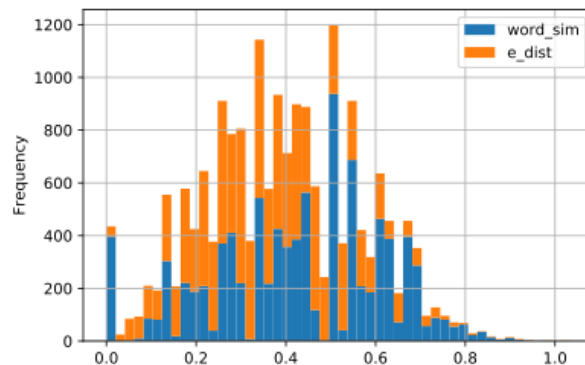
**35,000 examples: questions, answers, SPARQL programs, 9,000,000 web snippets**

# Human Paraphrasing

Compositionality	Example (Natural Language)
Conjunction	“What films star Taylor Lautner <b>and</b> have costume designs by Nina Proctor?”
Superlative	“Which school that Sir Ernest Rutherford attended has the <b>latest</b> founding date?”
Comparative	“Which of the countries bordering Mexico have an army size of <b>less than 1050</b> ?”
Composition	“Where is the end of <b>the river that originates in Shannon Pot</b> ?”

Type	%
WH-Modifier	18%
Major Reorder	22%
Minor Reorder	42%
Synonyms	54%
Skip Words	27%
Add Words	29%

Prevalent phenomena in paraphrasing



Machine question vs Natural language edit distance



# Paraphrasing Analysis

Type	Machine Generated Questions	Paraphrased Questions	%
WH-Modifier	<b>what</b> movies does Leo Howard play in and that is 113.0 minutes long?	<b>Which</b> Leo Howard movie lasts 113 minutes?	18%
Major Reorder	Where did the actor that played in the film Hancock 2 go to <b>high school</b> ?	What <b>high school</b> did the actor go to who was in the movie Hancock 2?	22%
Minor Reorder	what to do and see in Vienna Austria and the number of <b>building floors is 50</b> ?	What <b>building</b> in Vienna, Austria has <b>50 floors</b> ?	42%
Synonyms	where does the body of water under Kineshma Bridge <b>start</b>	Where does the body of water under Kineshma Bridge <b>originate</b> ?	54%
Skip Words	what movies did Miley Cyrus play in and <b>involves organization</b> Cirkus?	What movie featured Miley Cyrus and involved Cirkus?	27%
Add Words	what to do if you have one day in Bangkok and the place is an amusement park that opened earliest?	Which amusement park, <b>that happens to be the one that</b> opened earliest, should you visit if you have <b>only</b> one day to spend in Bangkok?	29%

# Model

# Training Data

Option 1

**Question**

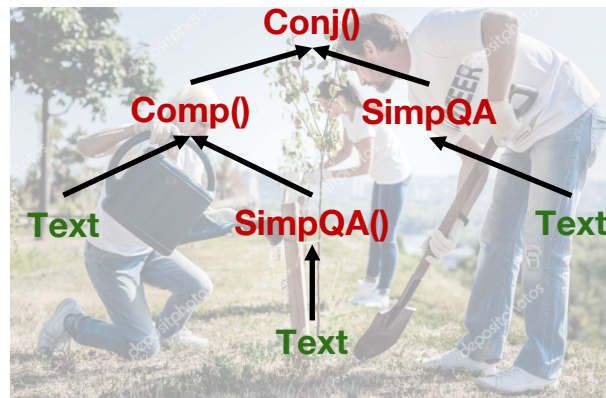
**Answer**

**Google**

**Hard to train with few samples**

Option 2

**Question**



**Hard for humans, expensive**

# Training Data – Noisy Supervision

**Generate Machine Questions  
in pseudo language**

*what films have taylor lautner starred in  
and in which costumes where designed by Nina Proctor*

What do we know?

1. Question Compositionality
2. Best split point of the machine generated question

**Paraphrase using  
Amazon Mechanical Turk**



**Human**

*What films star Taylor Lautner and have  
costume designs by Nina Proctor?*

**How to split the paraphrased questions?**

# Training data: alignment

*what films have taylor lautner starred in and in which costumes where designed by Nina Proctor*

Similarity Measure

*What films star Taylor Lautner and have costume designs by Nina Proctor?*

“Noisy” supervision

**Conj**(, What, films, star, Taylor, Lautner, and, “,” , have, costume, designs, by, Nina, Proctor, )

# Output Representation

## Conjunction

“What films star Taylor Lautner and have costume designs by Nina Proctor?”



program

**Conj**(, What, films, star, Taylor, Lautner, and, “,”, costume, designs, by, Nina, Proctor, )

## Composition

“Where is the end of the river that originates in Shannon Pot?”



program

**Comp**(, the, river, that, originates, in, Shannon, Pot, “,”, Where, is, the, end, of, %**VAR**, )

## Simple

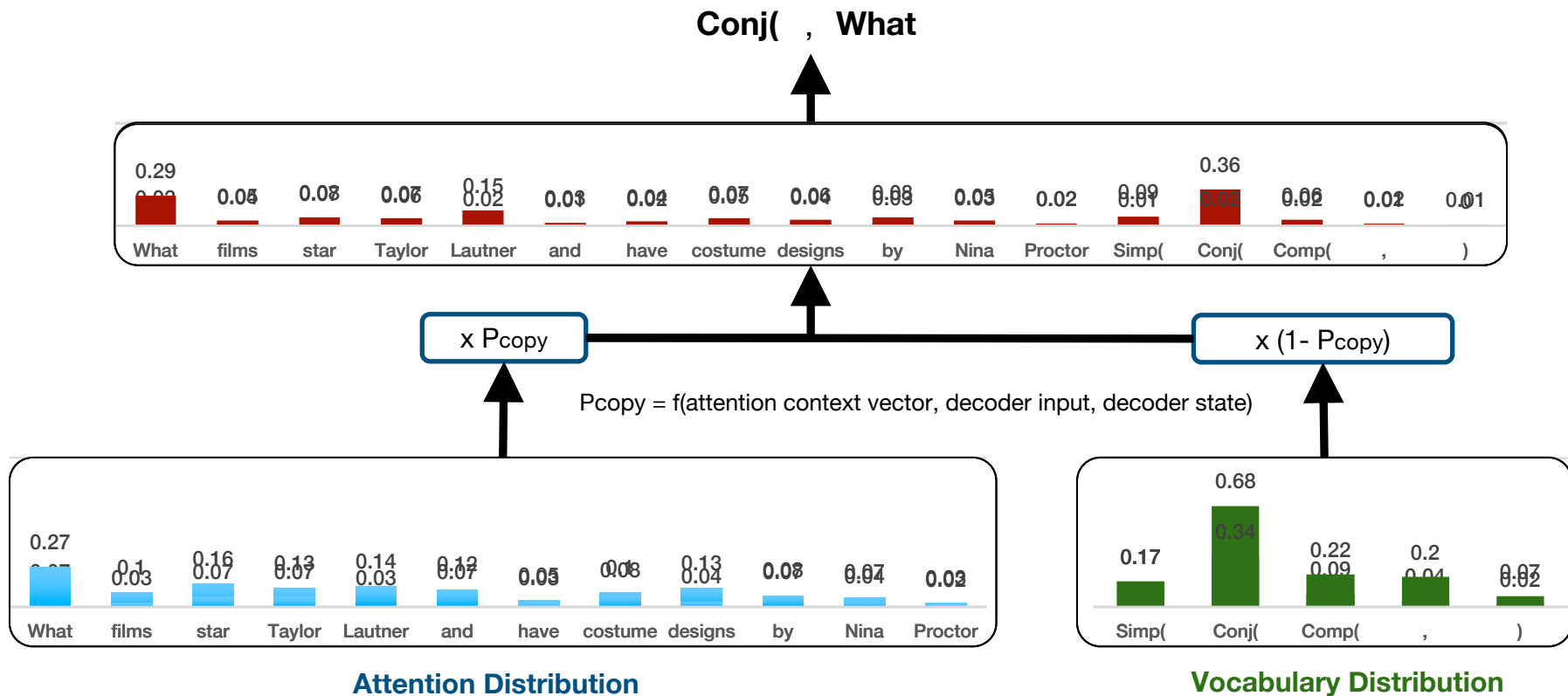
“Who is the director of the Matrix”



program

**Simp**(, Who, is, the, director, of, the, Matrix, )

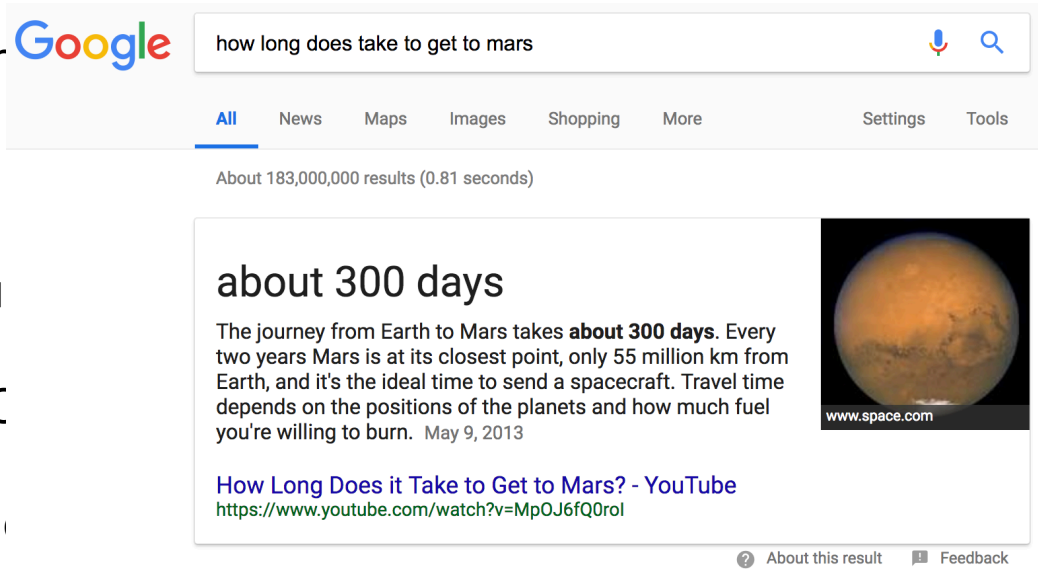
# Pointer Generator



# Baselines

- Google Box – answer at the top of google results

- SimpQA – Sim



- SplitQA – Our

- RCQA – Docu

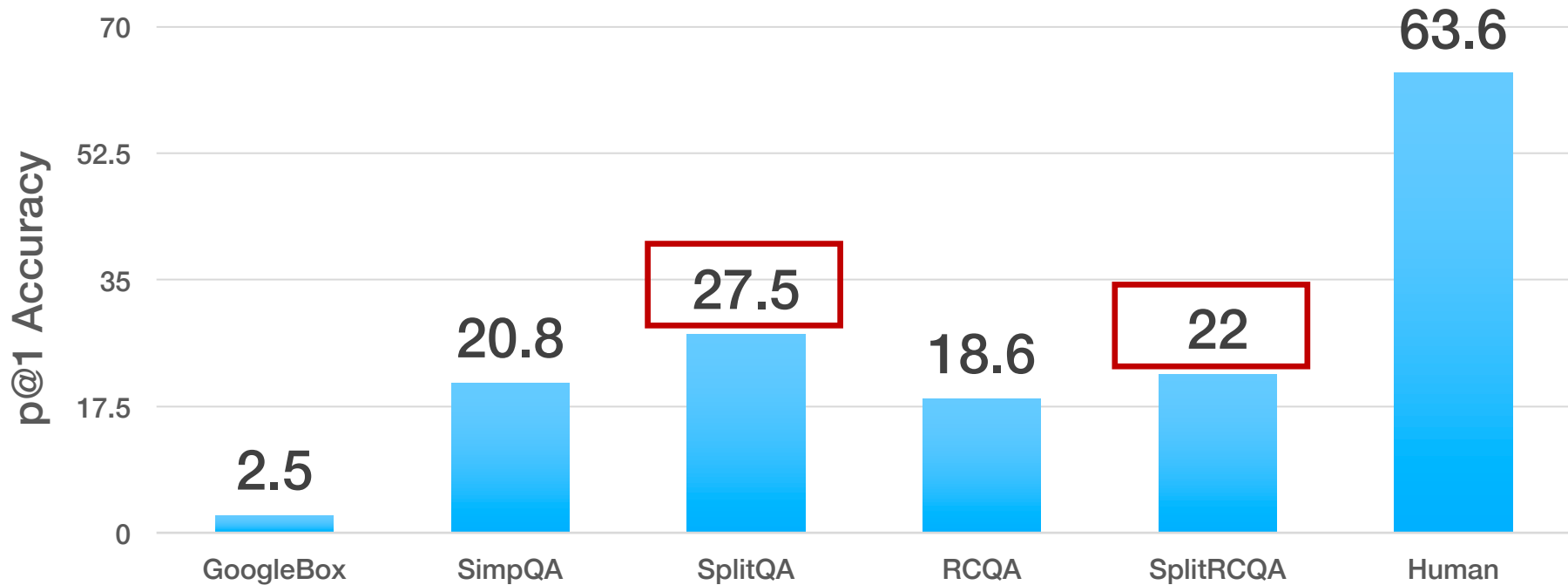
- SplitRCQA – C

- Human – 100

question as is



# Results



# Analysis

Noisy Supervision	Pointer Network
what movies does Leo Howard play in and that is 113.0 minutes long?	Which Leo Howard movie lasts 113 minutes?
Where did the actor that played in the film Hancock 2 go to high school?	What high school did the actor go to who was in the movie Hancock 2?
what to do and see in Vienna Austria and the number of building floors is 50?	What building in Vienna, Austria has 50 floors?
where does the body of water under Kineshma Bridge start	Where does the body of water under Kineshma Bridge originate?
what movies did Miley Cyrus play in and involves organization Cirkus?	What movie featured Miley Cyrus and involved Cirkus?
what to do if you have one day in Bangkok and the place is an amusement park that opened earliest?	Which amusement park, that happens to be the one that opened earliest, should you visit if you have only one day to spend in Bangkok?

# Future work

## What were the question answering publications presented in the recent NAACL?

question answering

About 1,140,000 results (0.06 sec)

[CITATION] The process of **question answering**: A computer simulation of cognition

WG Lehnert - 1978 - Lawrence Erlbaum Associates

☆ 59 Cited by 565 Related articles

[PDF] The TREC-8 Question Answering Track Report.

EM Voorhees - Trec, 1999 - trec.nist.gov

Abstract The TREC-8 **Question Answering** track was the first large domain-independent **question answering** systems. This paper summarizes the track by giving a brief overview of the different approaches taken.

☆ 59 Cited by 819 Related articles All 15 versions

Learning surface text patterns for a **question answering** system

D Ravichandran, E Hovy - Proceedings of the 40th annual meeting

In this paper we explore the power of surface text patterns for open-domain **question answering** systems. In order to obtain an optimal set of patterns, we use a method for learning such patterns automatically. A tagged corpus

☆ 59 Cited by 976 Related articles All 28 versions

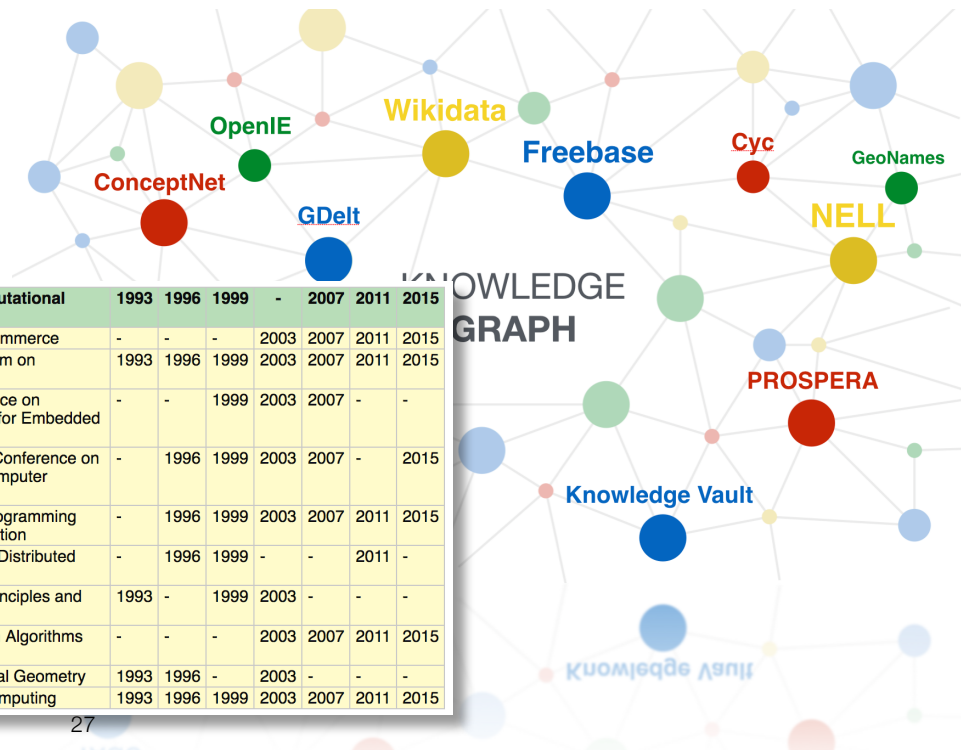
Discovery of inference rules for **question-answering**

D Lin, P Pantel - Natural Language Engineering, 2001 - cambridge

One of the main challenges in **question-answering** is the potential for ambiguity in the expressions in texts. While human inference rules such as 'X writes Y' implies 'X is the author of Y' in

☆ 59 Cited by 676 Related articles All 18 versions

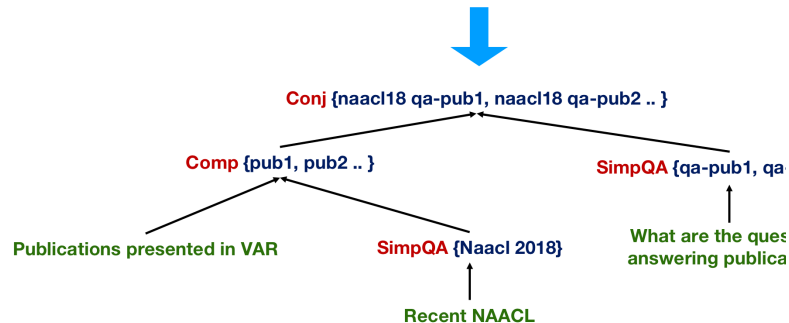
CCC	IEEE Conference on Computational Complexity	1993	1996	1999	-	2007	2011	2015
EC	ACM Conference on Electronic Commerce	-	-	-	2003	2007	2011	2015
ISCA	ACM/IEEE International Symposium on Computer Architecture	1993	1996	1999	2003	2007	2011	2015
LCTES	ACM SIGPLAN/SIGBED Conference on Languages, Compilers, and Tools for Embedded Systems	-	-	1999	2003	2007	-	-
METRICS	ACM SIGMETRICS International Conference on Measurement and Modeling of Computer Systems	-	1996	1999	2003	2007	-	2015
PLDI	ACM SIGPLAN Conference on Programming Language Design and Implementation	-	1996	1999	2003	2007	2011	2015
PODC	ACM Symposium on Principles of Distributed Computing	-	1996	1999	-	-	2011	-
PPoPP	ACM SIGPLAN Symposium on Principles and Practice of Parallel Programming	1993	-	1999	2003	-	-	-
SPAA	ACM Symposium on Parallelism in Algorithms and Architectures	-	-	-	2003	2007	2011	2015
SoCG	ACM Symposium on Computational Geometry	1993	1996	-	2003	-	-	-
STOC	ACM Symposium on Theory of Computing	1993	1996	1999	2003	2007	2011	2015



# Summary

## Framework

What were the question answering publications presented in the recent NAACL?

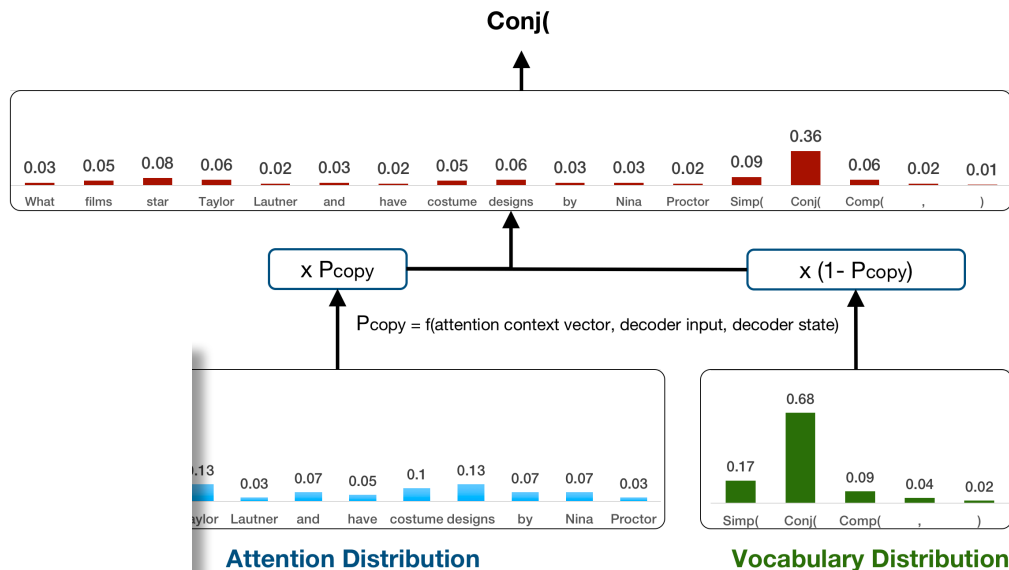


## Dataset

```

{
  "ID": "WebQTrn-2388_70cb5f02c23208a8369c961136b54b8e",
  "WebQSP_ID": "WebQTrn-2388",
  "answers": [
    {
      "aliases": [
        "The Adventures of Sharkboy and Lavagirl 3-D"
      ],
      "answer": "The Adventures of Sharkboy and Lavagirl",
      "answer_id": "m.06crgb"
    }
  ],
  "composition_answer": "taylor lautner",
  "compositionality_type": "conjunction",
  "created": "2017-10-26T02:55:34",
  "machine_question": "what films have taylor lautner starred in and in which costumes where designed by Nina Proctor",
  "question": "What films star Taylor Lautner and have costume designs by Nina Proctor?",
  "sparql": "PREFIX ns: <http://rdf.freebase.com/ns/>\nSELECT DISTINCT ?x\nWHERE {\nFILTER (?x != ns:m.07ldhs)\nFILTER\n\"webqsp_question\": \"what films have taylor lautner starred in\"
  
```

## Model



# Thank You!

## Complex Web Questions

[nlp.cs.tau.ac.il/compwebq](http://nlp.cs.tau.ac.il/compwebq)

[alontalmor@mail.tau.ac.il](mailto:alontalmor@mail.tau.ac.il)

"Computer: Analyse the distribution of the pieces that we have, correcting for changes in star configurations over four billion years, then extrapolate for the missing piece"  
(Star Trek, The Chase)

[Leaderboard](#)

[Paper](#)

[Download Dataset](#)